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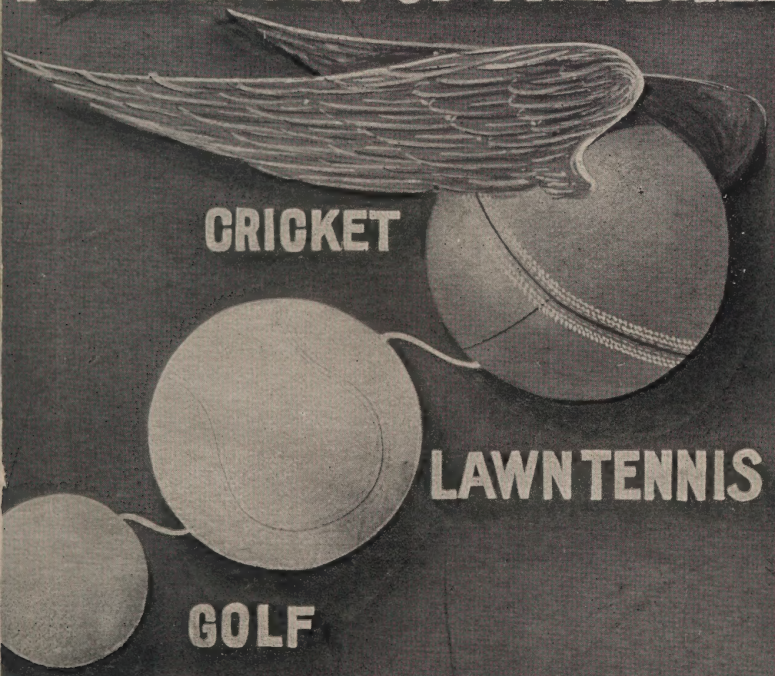
SWERVE

OR

THE FLIGHT OF THE BALL



P. A. VAILE

ELLIOTT & FRY.]

THE MARQUESS OF GRANBY

PRESIDENT OF THE M.C.C.

SWERVE

OR

THE FLIGHT OF THE BALL

BY

P. A. VAILE

4006.145

AUTHOR OF MODERN LAWN TENNIS, GREAT LAWN TENNIS PLAYERS, &c.

ILLUSTRATED BY EXPLANATORY DIAGRAMS

LONDON
J. TAMBLYN
1905

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PREFACE.

This book consists of articles contributed by me to *The Field*, under the headings of Cricket, Golf, and Lawn Tennis. I am enabled to reprint them by kind permission of the Proprietor of that deservedly high authority on sport. The Lawn Tennis player or Golfer who happens to buy it may at first sight suspect me of paying scant attention to his game. He may say, "I want to know about the flight of the Golf ball," or "the Lawn Tennis ball," as the case may be, and here is only one short chapter about each. I could, no doubt, have elaborated the description of the flight of both the golf ball and the lawn tennis ball until I had made this hand-book into a bulky volume, but there is in this little treatise really no necessity to thrash out over and over again the flight of each particular ball, for the same general principles govern the flight of the golf ball and the lawn tennis ball, as those

which regulate the conduct of the cricket ball while it is in the air.

Of course, if one were to use a lawn tennis ball of the size of a cricket ball, he would get a much greater swerve with it than he would with the cricket ball, for there is the same air-resisting area but a much lighter body, which naturally is less capable of fighting the air resistance than its solid relation.

This book will be found to contain nearly all that the cricketer wants to know about spin, and it should teach the golfer or lawn tennis player who desires to know these matters quite enough to make him study the matter for himself and perhaps seek further information.

Later on I may possibly elaborate this book, and publish it with photographs showing the holds of some of our leading swervers. The scope of this work does not, however, permit me to do that here. I have shown the various spins required to produce certain results, and any man who can use his fingers must be able to get these without difficulty.

The explanation of off-break with apparent leg-break delivery should be very interesting to cricketers and lawn tennis players. The ball described by me, which I have never seen bowled

in first-class cricket, namely the leg break with apparent off break action is a particularly deadly change and should be assiduously cultivated by left handers.

It should be borne in mind that although for purposes of illustration some of the swerves are shown as starting almost directly they have left the bowler's hand, in reality the swerve does not generally take place until much nearer to the end of the flight; and also that the swerve is in nearly every case exaggerated, for if drawn to scale it would be imperceptible.

The bibliography of the flight of the ball is not extensive. I am aware that some able papers have been written on the subject, but to find these involves much loss of time. This is my excuse for presenting these articles in book form.

This is, so far as I have been able to ascertain, the first and only book on the Flight of the Ball. The subject is of such importance to sportsmen that it is remarkable that it has not received more attention than it has.

Although I am dealing here principally with Cricket, Lawn Tennis and Golf, it is obvious that the base ball, and indeed all other balls, are subject to the same influences and rules as those herein shewn and set out.

I have referred later on to the fact that I believed it possible to obtain swerve in a vacuum owing to the faster movement of one side of the ball. I know that the weight of scientific opinion is against me in this matter. However it is purely an academic question for we do not play in a vacuum so I need not go any further into it. The soundness or otherwise of that contention does not in any way affect our practical results obtained in the atmosphere.

P. A. Vaile.

CRICKET.

Swerve in Bowling.

IN dealing with English Lawn Tennis recently I was astonished to discover how little is known of the flight of the ball, and the effect of spin on the passage of the ball through the air, and on its conduct on striking the ground. I am inclined to think that, in a great measure, the same state of affairs exists with our cricketers. I saw an account recently of an interview with George Hirst, the famous cricketer, in which a newspaper reporter had sought to ascertain, for the benefit of the readers of his paper, how the celebrated cricketer obtains his swerve.

I immediately came to the conclusion that the astute player, in the first place, had no desire to advertise the knowledge which he possesses, and, in the second place, that he really does not understand quite clearly how or why he does swerve. I may be wronging him, but I am content to take that risk. I

have seen photographs of him, and he appears to me to be a genial and forgiving type of man, as, indeed, I am informed, and verily believe he is; moreover, if I am wrong in my estimate of his character, I should think, from the aforesaid photographs, that my condition is at least as good as his, and, if that hope should fail me, unless I am wofully mistaken, I should "have the foot of him" for a sprint of a few hundred yards.

I was talking the matter of swerve over with one of the crack bats of England's champion team, who, I may say, is by no means the worst bowler in that team, and he expressed his opinion that a bowler can make a ball swerve when it has no spin whatever on it. This is, I consider, even with a wind, next to an impossibility. It occurred to me, that, if there is, as I suspect, so much uncertainty as to the cause of swerve and break in the highest quarters, it would not be uninteresting to cricketers, lawn tennis players, and base ballers, if I endeavoured to elucidate for their benefit the causes of swerve and break, and this I intend to do as clearly as I can, and without any undue technicality.

I have not studied this subject very deeply, but I have every confidence in putting my ideas before

players, for they are the results of practical application of information which I have acquired in my long association with that thrice-blessed shape, the sphere.

I am not, nor ever was, afraid of being proved wrong, and if anyone is capable of doing it in this matter I shall not be sorry, for he will have to add something to the knowledge of England's national sport, and I shall thus have achieved my object, which is simply to improve the great game of cricket, and any others which may be capable of receiving benefit from a more complete knowledge of the influence of spin on the flight and break of a ball.

It is my intention to dispense as much as possible with technical terms in this article, but it is absolutely essential to a proper understanding of my explanations that my readers should understand what is meant by the plane of the spin. This is shown in Fig. 1. I may say that nothing in any of the figures is drawn to scale. In Fig. 1 the dotted lines represent the seam of the ball, and you are supposed, in all the diagrams, to be bowling from this wicket to the other. If you deliver the ball with pure overspin, it leaves your fingers spinning from A to B, and proceeds down the pitch, if it goes straight, so that the line C B

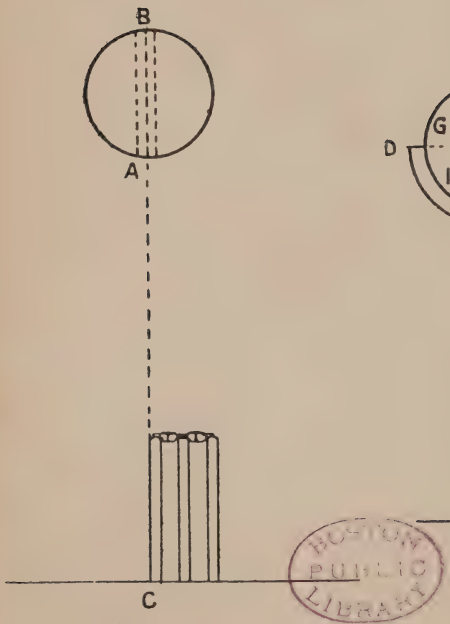

FIGURE 1.

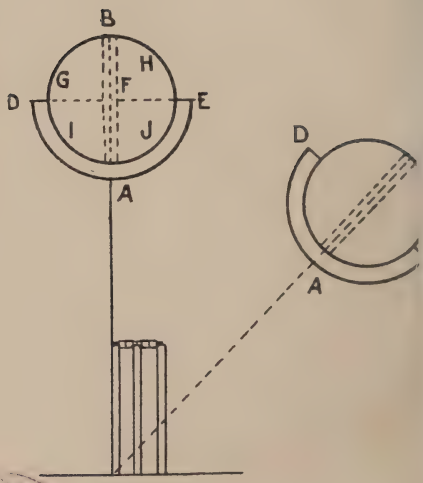

FIGURE 2.

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is always bisecting it; in other words, so that the seam is always at a right angle to the ground. This imaginary line C B shows, then, the plane of the line of flight of the ball, and also the plane of the spin of the ball, and these two very frequently coincide, as will be seen later.

In order to make this very clear, I shall refer to Fig. 2. Here, at one wicket, and looking away towards the other, I have, in my mind of course, erected an iron stand C A, with the semi-circular top D A E, and between the points D E, I have, on the axis or axle D E, hung a cricket ball, F. If you brush your hand upwards against the ball from A to B, you will cause it to spin forward and away from you, towards the other wicket. This is pure over-spin. I am in all cases taking the direction of spin from the point of last contact with that which produces it.

Now cut away the segments of the circumference of the ball, G H I J, and you have but the seam A B left. This is now practically a wheel, and it is spinning at right angles to the earth. Whatever angle this wheel is revolving at denotes the plane of spin of the ball.

Let us imagine that the stand A C is hinged at C. Bend it over as shown by the dotted line, C A. There is still the same over-spin on the

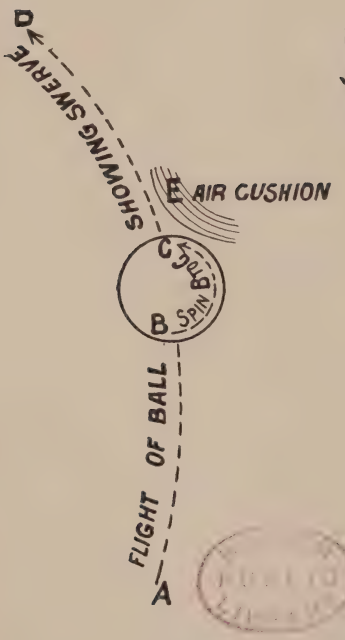

FIGURE 3.

FIGURE 4.

ball, but the axis of spin A B is at an angle of approximately 45° to the pitch, and nearly so will also be the flight of the ball if the wind and spin are sufficient, as I shall show later on. I shall hereafter call the axis of spin the axle, as that word is more generally used and understood, and practically means the same thing. It will be seen on looking at the dotted stand that the plane of spin is through the line C B.

These figures will, I think, show clearly what is meant by plane of the line of flight and plane of spin. In Fig. 2 the plane of the line of flight of the ball on the left hand stand is the imaginary wall C B which extends right down the pitch, and theoretically bisects, or cuts into halves, the ball F all the while it is progressing towards the other wicket.

It is a common notion that the cause of the ball swerving in the air is the friction caused by its spinning up against the cushion of air which is in front of it even as a billiard ball does against the cushion of the table. A study of Fig. 3 should be sufficient to show that this is not so.

A ball which is delivered at lawn tennis, or any other game, with a strong spin B to C will swerve in the air, following the invariable tendency of all

spinning balls, in the direction of the spin, which carries it along the line A D. Now if it were the spin of the ball (as at billiards) on the air cushion E which caused the swerve, the ball would, like a billiard ball, take its side off the cushion E and swerve towards D of Fig. 4 instead of, as it invariably does, away from it. I think we may count this theory out. Fig. 3 is a plan: that is, you are looking down on top of a ball which is spinning on a vertical or upright axle, and is proceeding down the line of flight A D.

Having dismissed this theory, we must endeavour to find a better. It is well known that the top of a carriage wheel in motion travels faster than the bottom. To many this will sound absurd, yet it is not so. The top has two motions, the progress through the air and the forward revolution or overspin, to use the sporting term. The bottom also has forward motion, but at that portion, of course, the tyre is travelling backwards, so that always that part of the wheel is travelling more slowly than the top. Of course, if the carriage were lifted from the ground and the wheel simply spun round the bottom would move as fast as the top; but it must be remembered that when the carriage is in motion the wheel has a moving, progressing axle, so that the top gets the benefit

of two forward motions, whereas the bottom has a forward minus a backward movement. Any spinning ball which is progressing through the air is to all intents and purposes, excepting for the want of contact with earth and the relation between the paces of spin and progress, similar to the wheel of a moving carriage.

Fig. 4 is a plan of a ball progressing through the air on an upright axle with spin from B to C, and the plane of spin, let us say, at present practically parallel to the surface of the pitch. The side B C is going faster and stronger than the side C G. Imagine A C the pole of a waggon, and B C and C G horses attached to such waggon. B C is a stronger pulling horse than G C; what usually happens then? The strong horse bores the weaker one across the road, and so it is in this case. Of the Siamese twins B C is trying to go faster than G C, who is endeavouring to lag behind, so B C is naturally dragged across out of the line which he would keep but for his slow half, which hangs on to his left hand.

Now we have to consider that most important point as to the influence of the air on the flying, spinning ball. In fig. 4 E and F represent the air as it is split open by the passage

BALL JUST DELIVERED BY BOWLER
SPIN A TO B
A
B
BALL AT OTHER WICKET
F
E
G
A
D
F
B
C

FIGURE 5.

of the ball through it. B C is rushing into and brushing violently against the cushion of air F on BC's side. This cushion is continually pressing on the side B C from C to H, which, with its strong forward movement, resists such pressure. On the other side the air E as it sweeps by and round C G finds little resistance, for it and C G are both going the same way, so that it follows, as a projectile always seeks the line of least resistance, that B C, who is continually receiving a glancing pressure from C to H, finds out that, as G C is not resisting on his side, it is easier for him to edge over and "take his water." This he proceeds to do, and this is how swerve is produced. Bearing in mind this explanation, it stands to reason that the stronger the wind that is blowing, provided it comes from the right quarter, the greater will be the swerve which may be obtained.

Break is in all cases practically due to the same cause. The strong forward-spinning half beats the weak retreating half. In fig. 5 the bowler has delivered the ball with a strong spin from A to B. The ball progresses towards the other wicket with its plane of spin almost parallel to the wickets—in other words, spinning across the pitch until it strikes the ground near

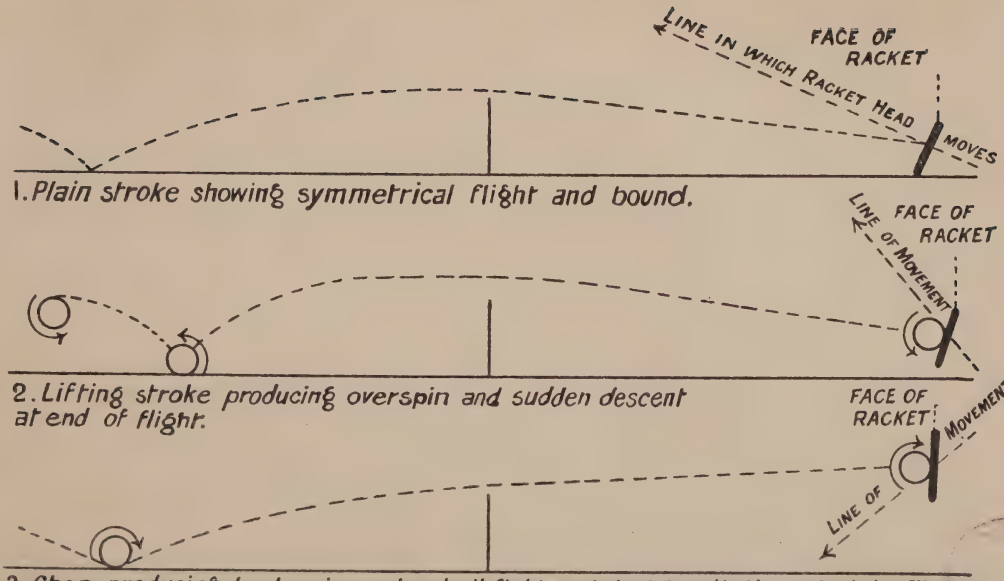
LINE IN WHICH RACKET HEAD MOVES
FACE OF RACKET
1. Plain stroke showing symmetrical flight and bound.
LINE OF MOVEMENT
FACE OF RACKET
2. Lifting stroke producing overspin and sudden descent at end of flight.
FACE OF RACKET
MOVEMENT
LINE OF
3. Chop producing back spin and as ball fights against gravitation straight flight and shooting bound.

FIGURE 6.

the other wicket, which exactly coincides with and is hidden by the wicket seen. It is spinning from A to B, and the half D E is going forward and the other half E F backwards. The spin A B is checked suddenly at C, but the ball, having the momentum of the spin, endeavours to continue its revolution, and, being temporarily held by the grip of the ball on the sward, it is deflected from its line of flight and bounds inwards towards the wicket, as shown by the dotted line F, thus producing a leg break.

I shall not have to deal very fully with break herein, so shall leave it with this explanation, which really covers every class of break. There is probably no doubt that to secure the best result of the spin the seam should be in the plane of spin, for it stands to reason that, especially with a new ball, the seam must get a slightly stronger hold of the pitch than the smoother portion of the ball would, and also that the player gets a better grip on the seam than he would on the smooth surface of the ball.

The principle of break is much more clearly understood than is that of swerve, so I do not propose to deal very fully with that subject. It must, of course, be remembered that to produce a leg or off-break it is not necessary that

the ball should be spinning in a vertical plane at right angles to the line of flight. A leg or off break can be quite readily produced if the ball be spinning in a vertical plane, but with such plane inclined inwards from either side of the wicket at an angle of anything up to, say, 50deg.

Varieties of Spin.

In dealing with this matter I shall include, for purposes of comparison, one ball which does not rightfully belong to this chapter. This is a a ball delivered without any attempt to produce spin, and which therefore leaves the hand with a minimum amount of revolution. I shall then divide the spins into the following classes: (1) Ordinary ball with practically no spin; (2) overspin, or forward spin; (3) backspin; (4) spin from right to left (vertical axle); (5) spin from right to left (leg break); (6) spin from left to right (off break); (7) spin from left to right (vertical axle).

In fig. 6 I give the flight of a lawn-tennis ball (1) when hit squarely, or with the plain face of the racket, (2) when hit with a lifting, or upwardly-glancing, blow, so as to produce overspin, (3) when hit with chop, or a downwardly-glancing blow, so as to produce backspin. This figure

has an important bearing on the question of swerving, and although I have here taken a tennis ball to illustrate my points, the same natural laws apply to all balls; so cricketers, baseballers, and others will find it time well spent to study it and the accompanying letterpress carefully.

The first illustration represents a ball struck fairly with the racket, without any cut, either upward or downward. This ball, therefore, has nothing to hasten its return to earth except gravitation and evenly distributed air pressure, nor anything to retard such return (beyond that which is common to all balls in flight, air friction) except the force of its propulsion through the air. It therefore returns to earth gradually as the force of the blow which propelled it dies away, and so is produced the even and symmetrical flight shown. As this ball has no "work" or spin on it, it naturally follows that its bound is practically at the same angle as that at which it came to earth, for the angle of reflection is about the same as the angle of incidence. To be less technical, a ball will, apart from any adventitious aids in the way of spin, rebound from the ground at practically the same angle as that at which it hits it. This return is equivalent to a plain ball without work of any kind.

The second illustration is the one of greatest importance to lawn-tennis players, cricketers and baseballers. To lawn-tennis players it gives the king of ground strokes, the lifting drive, to cricketers most of the swerves and the off break with leg break action, and to baseballers three out of four of their curls or swerves. Although I have here shown a tennis racket obtaining the spin, in cricket and baseball the fingers, of course, take the place of this implement, and, once the theory of obtaining the different spins is grasped, they get a precisely similar mechanical result. In the second diagram of Fig. 6 it will be seen that the face of the racket passes forwards, upwards, and obliquely at a fairly sharp angle against the ball, brushing up against it as it passes, and causing it to leave the racket spinning in the direction shown by the arrow. In delivering a ball with overspin the fingers and turn of the wrist have to do this. The result of this action is that, while the initial force of the stroke remains on the ball, the strength of its forward movement is sufficient to counteract the two forces, gravitation and overspin, which are fighting to overcome the force of propulsion.

Directly the power of propulsion weakens, gravitation gets to work, and as the strong,

fast-spinning side is on top already, it speedily worries down the weaker, retreating side, and the consequence is that the ball dives very suddenly to the ground in a curve frequently representing a quarter of a circle, so sudden is it. Immediately it touches the ground, the strong-spinning side, obeying the law of break (which is here the top of the carriage wheel), endeavours lustily to get away from the weaker, retreating half; but the drop has been so sudden that a stronger law here asserts itself. The angle of reflection, as I have said before, is the same as the angle of incidence. The force of the impact is sufficient to overcome the work on the ball until it leaves the ground, so it rises almost at the same angle as that at which it hit it. Then again the spin gets to work, aided by the propulsion, and, the top of the ball still striving to outrace the bottom, there is produced the curved bound shown in the second illustration in Fig. 6.

It is a very interesting fact that the flight of nearly every cut service or return where the spin does not fight against gravitation is of approximately the same shape. The difference lies principally, in fact almost solely, in the plane of rotation or spin. This fact is of the utmost

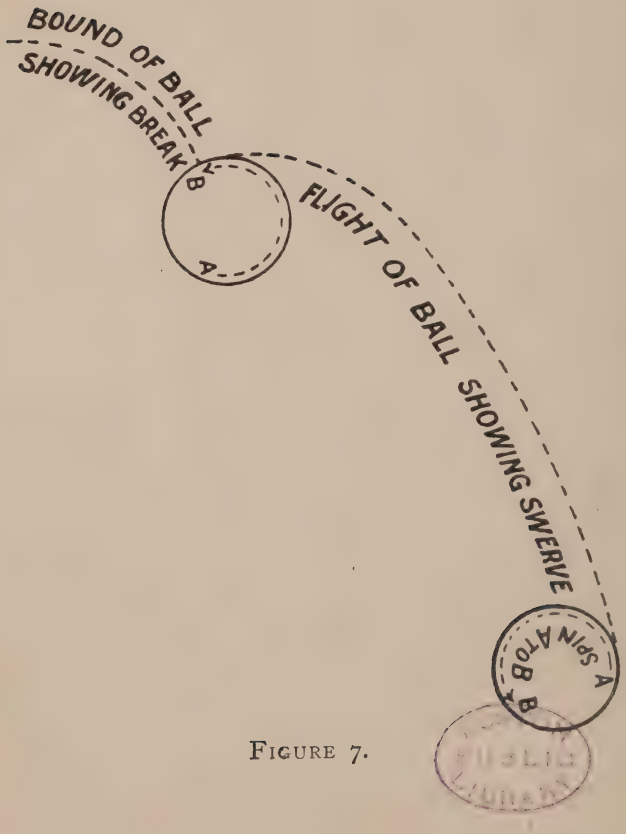
BOUND OF BALL
SHOWING BREAK
B
A
FLIGHT OF BALL SHOWING SWERVE
A SPIN
B TOP

FIGURE 7.

importance to anyone who desires to understand how to swerve, so I shall endeavour to explain it a little more clearly. In pure overspin the rotation or spin is, of course, endeavouring to assist gravitation the whole time, but immediately the plane of rotation is laid over to either side, so that it gets away from the vertical, you are beginning to contend against gravitation.

3. Backspin also causes the ball to fight against gravitation, for the strong spinning half is below, and the weaker half above, and the vigorous half is always trying to get up on top, but gravitation is too much for it, so it effects a compromise and goes as straight as it can from point to point. With a tennis ball, in 3, Fig. 6, having backspin, as the trajectory is so low, there is, I think, on contact with the ground, quite an appreciable amount of what engineers call "slip," like the engine wheels flying round on the rails without moving the engine. This takes place momentarily while the ball grips, and, in addition, it obeys the rule of the angle of reflection being equal to that of incidence, as the force of propulsion is so great that it refuses to allow the backspin to assert itself as it will with a slow ball of high trajectory, either in cricket or lawn tennis.

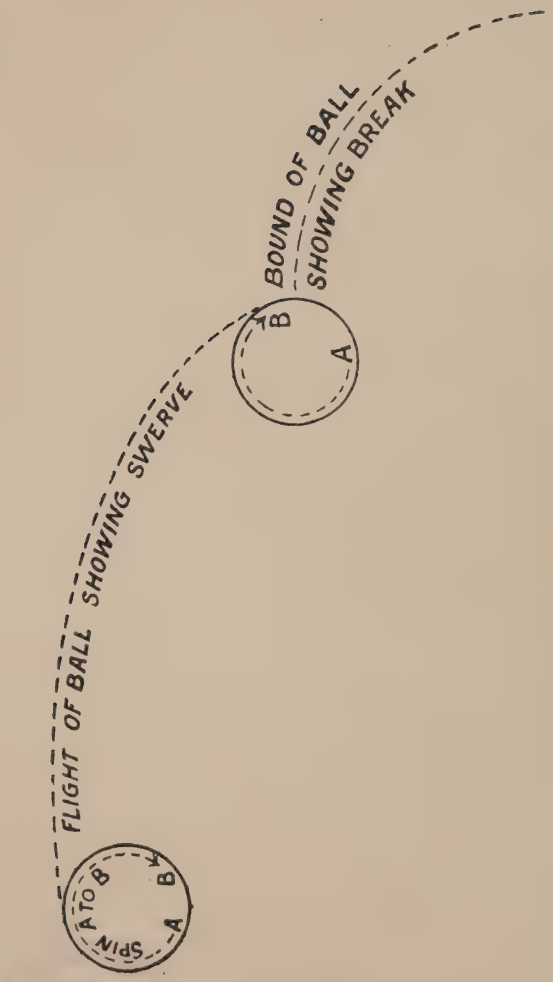
FLIGHT OF BALL SHOWING SWERVE
BOUND OF BALL SHOWING BREAK
A
B
SPIN
A TO B
B
A

FIGURE 8.

4. Spin from right to left (vertical axle).—Fig. 7 shows the action of this spin very clearly. If you examine the flight carefully, and allow for the slight contending against gravitation, you will see that this figure is approximately the same shape as the flight of 2, Fig. 6. It must be borne in mind, although I call this a vertical axle, that as a matter of fact it rarely is. I am giving you the "points of the compass" of spin, and you will have to so adjust your plane of spin as to obtain the best results you are capable of. This spin produces a leg break, but naturally of a less angle than the ordinary action.

5. Spin from right to left (leg break) was explained in Fig. 5.

6. Spin from left to right (off break) is so generally understood that I need not elaborate it here. The same applies to leg break, and I should not have mentioned that but as an example to show what actually causes break. If any illustration is wanted, you can supply it by putting the balls on the other side of the wicket, reversing the arrows and lettering, and changing the dotted line F over to the other side of the ball.

7. Spin from left to right (vertical axle).—Taken in conjunction with the preceding figures

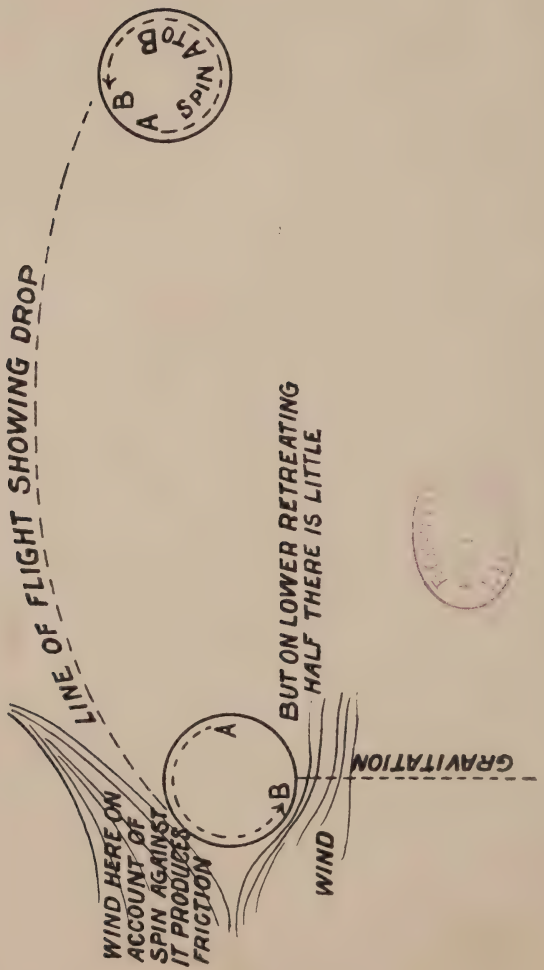
A TO B SPIN
B
A
LINE OF FLIGHT SHOWING DROP
WIND HERE ON ACCOUNT OF SPIN AGAINST IT PRODUCES FRICTION
A
B
BUT ON LOWER RETREATING HALF THERE IS LITTLE
WIND
GRAVITATION

FIGURE 9.

and letterpress, this requires little explanation. The same shape of flight is still apparent. See Fig. 8.

These, I think, are all the spins any ball is capable of. Any other spin, I think, must be merely a modification of some one of these, and, as a matter of fact, all swerves and breaks are obtained from modifications of those enumerated, which I may call primary spins.

Overspin.

The flight produced by overspin is shown in the second illustration in Fig. 6. This is how the baseballer gets his downward curve, and against a wind he can get a remarkable curl on, for he has wind, spin, and gravitation all fighting for him. This is shown in Fig. 9.

A skilful bowler, with full knowledge of the use of this overspin, can, against a wind, cause a most deceptive flight, as immediately the pace goes off his ball, and wind, spin, and gravitation get to work, it will drop far more quickly than it looks like doing, and will then, according to the angle of its descent and the amount of work and pace on it, either whip off the pitch, or get up very straight.

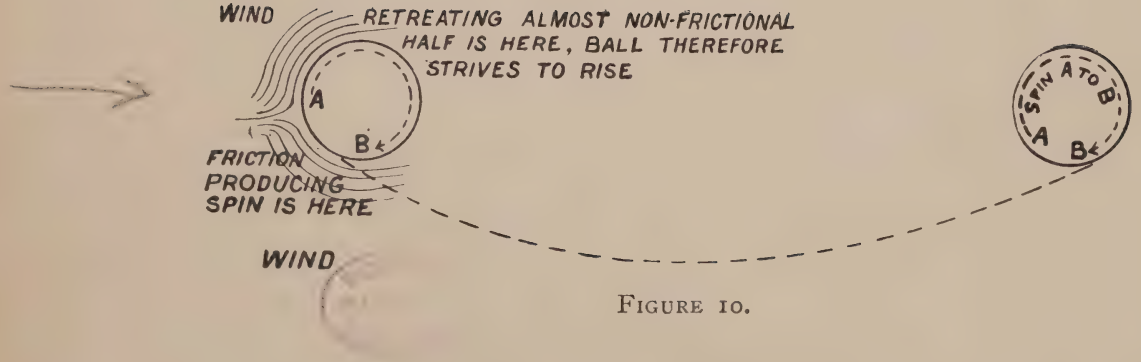
WIND
RETREATING HALF IS HERE, STRIVES TO RISE
ALMOST NON-FRICTIONAL BALL THEREFORE
A
B
FRICTION PRODUCING SPIN IS HERE
WIND
SPIN A TO B
A
B

FIGURE 10.

Backspin.

It always seems to me that this is quite the most intractable of spins, and this I suppose is naturally so. Practically in all overspins above the horizontal plane the ball is, although in some cases but slightly, assisting gravitation. Speaking from a purely scientific point of view, this, of course, is not so, as immediately the plane of spin forsakes the vertical there is a contending force, however slight, set up against gravitation. It may reasonably be contended that those spins near the horizontal plane do not in any way assist the natural law, but I shall not labour that point, for it is a certainty that, even if they do not willingly submit, they do not, as does the pugnacious backspin, actually fight directly against and temporarily overcome it.

The baseballer can get an upward curve with this spin, especially against the wind, which is always an assistance to a swerver, provided it comes from the right quarter. Fig. 10 shows how this upward curve or swerve is obtained. The friction producing spin is working on the wind, which it is resisting, and the ball is, as shown in the drawing, being forced upwards.

I might almost let the illustration of the primary spins and motions of swerve rest here,

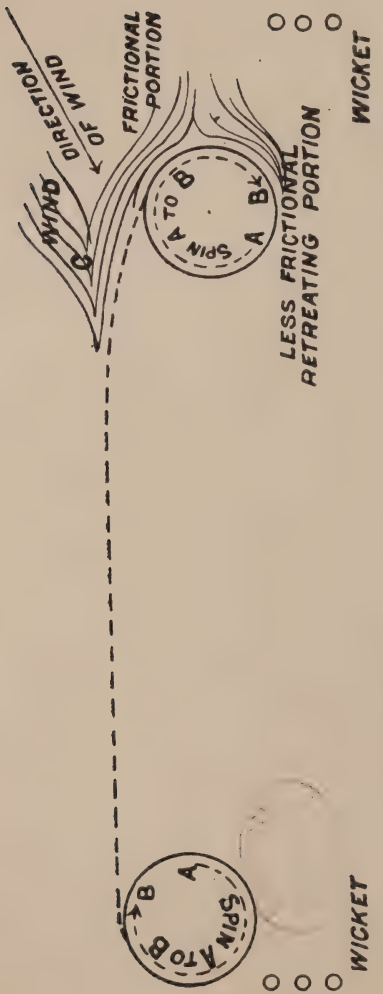
DIRECTION OF WIND
FRICTIONAL PORTION
SPIN A TO B
A
B
LESS FRICTIONAL RETREATING PORTION
WICKET
SPIN A TO B
B
A
WICKET

FIGURE 11.

for if you consider this figure a plan instead of an elevation it would clearly illustrate the action of the ball in an off swerve. Hold it up and look through the page from the back, and you have a leg swerve. This action (Fig. 10) causes the ball to hold up against the wind, to "swim" on it to an astonishing degree, and produces a much "longer" ball than it looks like at first at tennis or cricket.

Horizontal Spin.

Fig. 11 shows the action of the wind on horizontal spin, or an approximation thereto. This ball is spinning from A to B, and the wind C, coming out of the slips, is forcing it into the wicket, thus producing a swerve from the off.

Fig. 12 is the leg swerve, and here again may be seen how the wind, if in the right direction, assists a swerver. The wind here, as shown by the arrow, is steadily directing a glancing force on to the ball, so as to gradually edge it in towards the wicket.

Swerve.

I have, I think, indicated fairly clearly what I think it is which produces swerve. The same general rules govern the movement of all balls through the air, and it will be found that these remarks in most cases apply to all balls,

DIRECTION OF WIND
THIS HALF OF BALL FIGHTS AGAINST WIND
THIS YIELDS TO IT
WICKET
SPIN A TO B
B
A
A
SPIN A TO B
B
WICKET

FIGURE 12.

though, of course, in baseball, where the ball is always when hit volleyed, the question of break is eliminated.

Swerve may be obtained by pure rotation or spin. It is not, as is supposed by many cricketers, necessary to have a wind, although if there is a suitable one it is undoubtedly a great assistance. Swerve may be obtained in a dead calm.

Swerve is caused by the different paces on opposite sides of the ball, together with the consequent uneven pressure of the air on the opposite halves of the ball, as already shown.

A popular fallacy about swerve is that one must have a new ball to do it with. This is utterly incorrect. Any sphere will swerve if projected through the atmosphere with sufficient spin on it, even if the day be calm, provided always, of course, that its rate of progress through the air is not sufficient to overcome the spin. A fast bowler could not expect to get the same amount of break as a slow one, assuming the two to have an equal command of the ball.

I can make a tennis ball swerve in any weather, and, allowing for a cricket ball's greater weight, and for the fact that the spin is much slower, a bowler should be able to swerve in a similar manner if he thoroughly understands what he is

trying to do. If he does not, he is groping in the dark, and this unquestionably is what many of them are doing.

George Hirst says you must have a wind and one of the right sort, and he says his favourite wind is a long-slip wind. As a matter of fact, as I have before said, a wind is not necessary, but is, no doubt, very desirable, as it increases the possibilities of swerving very much. Hirst, however, seems to indicate that there is only one suitable wind. If a long-slip wind will give you off swerve, it stands to reason that you only require to reverse the spin and bowl into the leg country, and, provided you have a suitable wind, you will swerve from the leg just as you do from the off.

Hirst says "the seam of the spinning ball is always vertical." This almost certainly is an error, and, if not an error, then it is evident that the ball is not delivered in the best way to produce the maximum of swerve. "The seam of the spinning ball is always vertical" implies that the axle of the spin is horizontal, whether the ball is spinning across the pitch or with it from wicket to wicket. Now, neither of these spins can give the best result in swerve.

If the ball were spinning across the pitch on

a horizontal axle, it is propelled down the pitch revolving in the same manner as a rifle bullet does on leaving the barrel of a rifle. As it is an off break we are speaking of, we shall assume that the barrel of the firearm is rifled so as to produce spin from left to right.

A very prominent cricketer asked me how it is that a leg break does not swerve. My answer was, "Some leg breaks do swerve, and some swerves do leg break." However, as I knew he meant the common or garden leg break, I explained to him that, as shown above in the case of the off break, the ball is discharged practically like a bullet, so that the plane of spin and force of translation or progress are always in direct conflict, and thus the spin is neutralised until it gets its grip of the ground, as shown at G, Fig. 5, when its influence is immediately asserted, and it deflects the ball from its line of flight in a degree proportionate to the amount of "work" on it and the force of its progression.

Now, let us take the other proposition—that is, that the ball is spinning vertically down from wicket to wicket, its seam being in the plane of spin. This ball would swerve little, if at all, in response to a long-slip wind. Such a ball corresponds to the lifting drive at lawn tennis,

shown in illustration 2 of Fig. 6 which is mechanically the same as "overspin," shown in Fig. 9.

In this figure you may see the wind coming against the ball in a straight line. The plane of spin is vertical, lengthwise with the pitch. A long-slip wind would come glancing up against the side of that plane, and the spin will fight that wind for "all it is worth" while it has a turn left in it. This, I think, is obvious.

Turn now to Fig. 11, off swerve, which, although for explanatory purposes is shown with horizontal plane of spin, is in actual practice in cricket more generally at an angle of approximately between 35° to 40°. Here you will see the natural curl of the ball is away from the long-slip wind. There is a minimum of contention with the wind, and both spin and gravitation are prepared to assist the swerver to the utmost of their ability. It follows from this that no vertical spin is the best for producing swerve.

In this figure the wind may be seen edging the ball the way it wants to go, and that is the art of using the wind in swerving.

A long-slip wind meeting a ball which is going down the pitch with vertical overspin, as in Fig. 9, would certainly tend to make such a ball drop

short, and possibly would, if strong enough, deflect it slightly from its line of flight, but that does not alter the fact that it is not the right spin for a swerve from either side of the wicket

If this statement about vertical spin producing swerve were correct, simple overspin would, were the wind suitable, give you swerve from either side of the wicket. You will not find this borne out in practice, I am afraid. You must depend on modifying or amalgamating horizontal spin and overspin for your swerve.

George Hirst is made by his interviewer to say: "It all depends on the seam. The swerve can be done only with a new ball, and as soon as the seam gets knocked off there is an end of the swerve."

I have no hesitation in saying, and I hope I shall be able to prove, that this is quite a fallacy. There are two reasons which might make the seam a necessity: (1) To obtain a better grip of the ball, so as to be more easily enabled to spin it; (2) the possibility that, if the ball is delivered with the seam in the plane of spin and line of flight, that the air friction on the sewing and edges of the seam would tend still further to keep it to its original plane.

Both of these are feasible. The first is to a

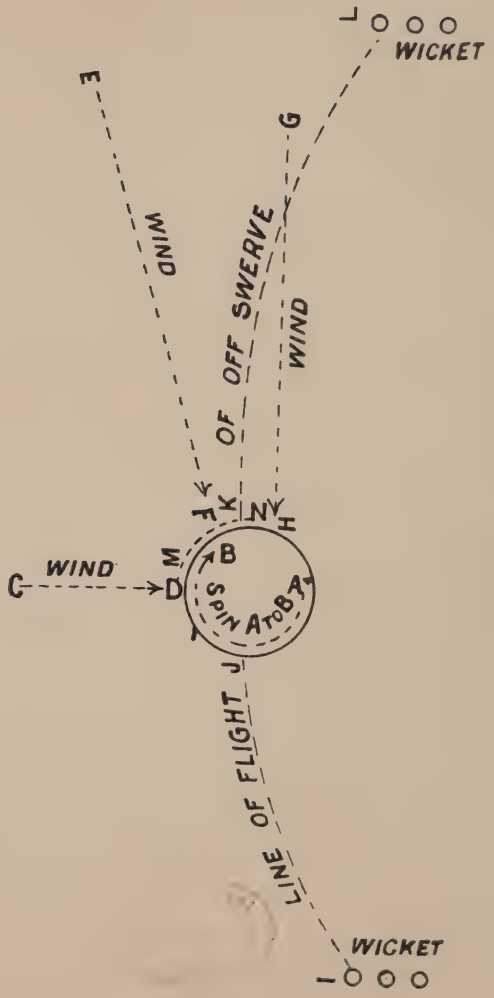
L
WICKET
E
WIND
G
OF OFF SWERVE
WIND
F
K
N
H
M
B
WIND
C
D
SPIN A TO B
A
J
LINE OF FLIGHT
WICKET
I

FIGURE 13.

considerable extent practical. The second, I am inclined to think, is nearly theoretical, although I believe it to be sound theory.

Suppose a ball to be fitted with a metal flange as an exaggerated seam. Now, there is no doubt that if you deliver that ball in any plane of spin which coincides with the metal flange, the flange will assist to keep it there. The extra friction of the seam of a new ball must, I think, act in the same way, but I do not believe to anything like the extent suggested by Hirst.

For instance, I have no more doubt than I have that I am now writing that you can make a cricket ball swerve so that the plane of spin would be across the seam.

Again, Hirst says that directly the seam is off swerve is off. I say this is not so. I can make a tennis ball, which has no seam that will assist spin, swerve on a calm day, and, on a very windy one I can make it swerve about 3 yards in the length of the court, which is 78ft. I can make any old ball (cricket or otherwise) swerve, and a cricket ball is not a law unto itself. So long as the right amount of the correct spin is there, and not too much pace, you can, especially if the wind is assisting, make a cannon ball swerve. Baseballers get all swerves—right, left, up, and

down, and many modifications of each; yet a baseball has not a seam answering to a cricket ball. It is stitched almost the same as a lawn-tennis ball. They, of course, get greater spin, but they also get greater pace to fight that spin.

Pace will sometimes kill swerve if the spin is not strong enough, but extreme pace and swerve are not irreconcilable, provided the spin is strong enough. This is very plainly demonstrated at baseball.

The art of swerving consists in producing such a plane of spin as shall not fight against your intended line of swerve, nor against the wind which may be blowing at the time of your delivery; at cricket, and, indeed, generally, to produce the best results, it should certainly be such a spin as does not directly contend against gravitation. The best result could not possibly be obtained from a vertical spin, be it a cross spin or simply pure overspin.

Now, as to the best wind to produce swerve. I have shown in Fig. 13 an off swerve. It is quite a mistake to think that the wind must come from any particular point of the compass to influence the ball sufficiently to obtain swerve.

Nearly, if not quite, half the compass is open

to him who knows how to use it. The wind C D will certainly assist an off swerve. Probably the best wind is that which comes from or about E F, and even a dead head wind like G H will assist; but I must say that I prefer it a point or two off the wicket towards E F, so that it strikes the ball in a glancing direction between the points M N, and so produces the flight I J K L. The same argument, of course, holds good on the leg side.

It should be borne in mind that the swerve takes place principally after the initial force of propulsion is off—that is, near the time when the ball will pitch on the ground in cricket or be hit by the striker in baseball. The reason for this, I think I have before explained, is that then, the force of propulsion being lessened, the ball has a chance to exert the force of its spin in the plane of rotation in which it finds itself, and as that is, or should be, generally speaking, in an angle of a nature which inclines it to assist gravitation, it seeks the ground in that plane, instead of dropping straight down.

It is a well-known juggler's trick to throw a card away and make it return to the thrower. This is a useful lesson in swerve. There is no wind, but the strong-spinning side is always

beating the weak retreating side. The card is generally thrown upwards at an angle of, say, 40°. It naturally continues to revolve in the plane in which it started, and, as it continues to swerve, it performs very nearly a circle, and returns to the dexterous spinner in the same plane of spin as that in which it left him. If, instead of throwing it upwards, he used the same angle downwards, it could not return. Gravitation would prevent it climbing the hill on the return journey. So in swerving at cricket, care must always be taken to enlist the aid of gravitation by using overspin and making your plane of spin incline inwardly towards the wicket, except in those rare cases when you employ backspin, and this, of course, with so heavy an object as a cricket ball cannot give you anything like the curve or swerve of the various modifications of overspin, which may be obtained on either side of the vertical plane of spin down to nearly an angle of 45°. When you get into this neighbourhood it soon becomes 'off' or 'leg,' as the case may be.

This is not so obvious as it may appear. Indeed, there is a very fine and subtle distinction as to the point at which overspin ends and leg or off comes in, as I hope to explain later

on. This is especially so in lawn tennis, where the American service, which corresponds to off-break with apparent leg-break action, can scarcely at times be distinguished from a pure fore-hand cut service, which corresponds to leg-break produced from a ball spinning from right to left on a vertical axle.

I have shown how these swerves are caused, and I am expecting a question, "How do you hold the ball to get these swerves?"

My answer to that is that it does not really matter much how you hold the ball, so long as you get the right plane of spin and enough of it; but there is generally a best way to do anything. You will not be trying to swerve and break before you have length, or perhaps I should say you ought not to be trying to. If you are, then I shall be glad I have not given you any information on the point. When you have some command of the ball you must get someone to show you how to hold it to produce leg and off breaks. When you have got these, simple modifications of the plane of spin from vertical cross-spin to overspin at an angle of about, say, 35°, will soon give you swerve.

It all depends on the plane of spin, and the speed of that spin. The dominant idea in

your mind must be the plane of spin which you wish to start the ball in.

Unquestionably wind and speed of spin are important factors, but they come afterwards. Reverting again to the question of how to hold the ball, I may say that I do not arbitrarily insist upon particular "grips" or "holds" either at lawn tennis or any other game, and my advice to you is to get as near as you can comfortably to that hold adopted by the best producer you know of that break which you want. I can show you for each break or swerve different ways of holding the ball which produce approximately the same result, but I cannot do so here, as for that purpose I require the aid of the photographer.

In these articles my chief concern has been to show exactly what causes swerve. I hope that cricketers and others may be interested in my explanations. If they are, and if there is any very general desire expressed for further knowledge on the subject, it will give me great pleasure to go more fully into the matter and supply my readers with action photographs of the hands of the most famous swervers as they are delivering the ball and also of my own methods.

THE ACTION OF THE AIR ON THE BALL.

I have already dealt with this matter in treating of the various kinds of swerve. For fear, however, that I have not made myself perfectly clear, I shall here risk repeating myself a little in the endeavour to place beyond any doubt what is in my mind with regard to the action of the air on a ball as it progresses through the atmosphere. There is no need for a diagram to represent a ball, without spin of any kind, meeting a wind coming in a direction exactly opposed to its flight. It is plain, I think, that there is nothing in this case to induce the ball to leave the original plane of its flight.

Let us now look at Fig. 15. This is a plan. In other words, we are looking down upon the pitch from above, and the ball is progressing rapidly from D to E, spinning in a horizontal plane on the vertical axle A, with strong rotation from C to B. This rotation alone is sufficient to cause it to desire to leave the straight line, but, in addition to this, we see the wind, F G, striking the ball a glancing blow at H. It then opens, and the great volume of it is directed on to that portion of the ball between H and I which is spinning strongly against it, and therefore producing considerable friction.

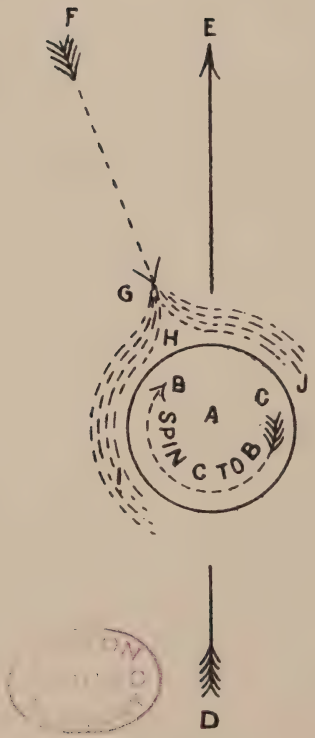

FIGURE 15.

Now, look what is happening on the other side. On account of the angle at which the wind is striking the ball, much more of the side towards the wind is exposed to its action than is the case on the other side. The wind sweeps across the small portion, H J, which is revolving with it, instead of spinning against it, as on the other side. The consequence naturally is that between H and J there is much less resistance than there is between H and I, and the H I portion of the ball, naturally trying to make things easy for itself, is all the time edging over to get into H J's track, and the more it edges the more the push of the wind is felt. This is why so many balls which swerve do all or most of their "business" at the end of their flight, particularly as then the force of propulsion is dying, and is thus allowing the spin more chance to exert its influence.

Off-break with Leg-break Delivery.

This is a matter which has proved of great interest to cricketers. It, however, seems to be a bit of a puzzle to most of our bowlers. This is because they do not know what to try for.

Again, it is simply a question of plane of spin or rotation.

This delivery is identical with the so-called American service at lawn tennis. I have fully explained the mysteries of this in '*Modern Lawn Tennis*.' I have given there, also in the '*Field*' of June 4, and in '*Lawn Tennis and Croquet*' of May 4, very full and exhaustive explanations how to produce the American service. If any cricketer wants further information on the off-break with leg-break delivery, he can get it by perusing these descriptions.

The off-break with leg-break action is produced by an overspin, with the plane of spin lying over at an angle of, say, about 50°, or at any angle before the overspin becomes leg-break. Overspin is not confined merely to the vertical plane. Sometimes you will deliver the ball so that, instead of being perfectly vertical, the plane of spin will be lying over a little, let us say about 15°. Well, so long as your spin keeps on, that ball will fly and bound in its plane of rotation, so that it will go through the air with its flight at an angle of 15° to the ground, and its bound

will be at the same angle. At least, that is what it would do if much lighter; but, being fairly heavy, and the spin not being very strong in proportion to its weight, a cricket ball merely strives a little, unless assisted by the wind, to fly in the plane of spin of the ball. The ball, however, directly it strikes the ground, does its best to bound in the plane of its rotation, so that, if it has been delivered with a plane of spin at 45° to the pitch, it will do its best to bound in the same plane. In other words, the ball flies and bounds on its side, if one may use the term when speaking of a sphere.

If you took a tin plate with a rubber edge and threw it down the pitch at an angle of 45° to the pitch, and spinning away from you, that plate would seek the ground at an angle of 45°, and, instead of continuing away to the side it apparently would be making for, it would remain in its plane of rotation and so break back apparently—but only apparently—in defiance of natural law.

Ordinary leg-break is a spin across the pitch

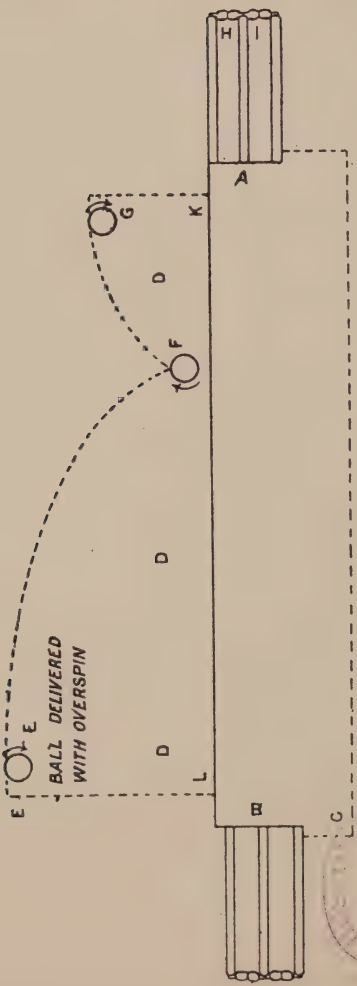

FIGURE 16.

from right to left. Off-break with leg action is overspin down the pitch, with the plane of spin at about 45° to 50°.

This is really a hard break to explain by lettterpress, even when assisted by ordinary diagrams. I have, therefore, resorted to a mechanical expedient, which should make it abundantly clear to anyone how the break is produced.

In Fig. 16 E is a ball delivered with pure overspin, and the curved lines, E F and F G, represent its flight and bound respectively. The plane of its spin is, of course, the wall D, contained within the lines E F, F G, G K, K L, and L E. Now, if the reader wants to understand this break perfectly, let him cut this figure round the wickets and the dotted lines on the off and fold the wickets at the bottom, so that they will stand upright, as though pitched in the ground. Then let him fold the wall, D, along the line, L K, so that it also will stand upright. This will amply repay him for his trouble. When D is upright the plane of spin is vertical, and the bound, F G, brings the ball on to the

off stump, H. I want the reader to consider that the ball, E, is being delivered all the time, and is continually travelling down the lines, E F, F G. Now bend the wall or plane of spin, D, over until the ball, E, is over the point, C. The plane of spin of the ball, E, is altered to nearly 50°. The ball is being delivered from the other side of the wicket, and its bound brings it back from the off stump, H, on which it pitches at F, to the leg stump I, because it is overspin striving to keep in the plane of spin D. It must be remembered that the figures are not to scale, and therefore that when D is bent across to C, the swerve, E F, is, of course, exaggerated.

This little device perfectly explains the seeming eccentricity of the American service and of this break. It is really a natural bound, but so many in trying it get the plane of spin down too low, and so overspin ceases and leg-break creeps in. This makes these breaks very valuable, for it is so hard for a batsman to tell which he is getting. Left-handed bowlers who desire to obtain leg-break with off-break delivery should

remember that this is "on" just the same as is the reverse American service, which is apparently an off-break, yet comes in from the leg. A bowler who understands how to do it may, of course, add both these to his repertory, and there can be no doubt that they are a very deadly addition in the hands of a capable exponent.

We are the champions of the world at cricket, yet, so far as I am aware, no bowler here has these deliveries. I shall at any time be pleased to elaborate my illustrations if anyone who really desires to acquire these valuable deliveries has any difficulty in mastering my explanations.

Conclusion.

I trust that my readers will not consider these articles an attempt at a scientific treatise. I have endeavoured to keep right away from that. In fact, I have purposely misused terms where by so doing I thought I might render my meaning clearer. For such words as rotation and axis I have substituted spin and axle. Personally, I do not think it is much improvement;

but, in any event, I wish it to be clearly understood that I make no pretence to scientific knowledge on this subject, beyond that which I have acquired from many years of sympathetic association with the grandest shape known to man, the sphere. I have here jotted down what seem to me a few obvious facts, which I have never seen in print anywhere, but they may be there, nevertheless. I am confident of the correctness of the reasons I give when accounting for swerve. However, if I am wrong, we shall, no doubt, soon have a few wiser people who will put us right, and there will be no serious harm done.

The explanation of off-break with leg action may, I think, be taken as quite correct. I cannot see any other possibility by which it can be obtained, and I can get both it and the reverse break by the method described by me.

LAWN TENNIS.

The Value of Rotation.

THE king of ground strokes, the fore-hand drive with lift, which should be the foundation of every lawn tennis player's game, is not used in England. This can only be on account of the fact that its many virtues are not appreciated. The stroke is played with a glancing blow, which travels forwardly, upwardly, and obliquely across the intended line of flight of the ball, as shown in Fig. 1. It is to a very great extent a half-arm shot—that is to say, the arm above the elbow does not enter into the stroke in anything like the same way as the forearm, which brings the racket up with a sharp brushing motion across the ball, which is thus projected on its course with a large amount of "roll" or "lift."

So far as I am aware, there is no settled technical term for this overspin, for such it is.

FIGURE 1.

Forehand drive with lift.

I have heard it called "drop," "top," "rib," "roll," "loft," "lift," "up rib," "up lift," and so on in different parts of the world. "Up cut" is the most correct term which can be used to describe it, but it is more generally called "lift," so I shall use that term to express it.

In the figures nothing is drawn to scale. It will be seen at a glance that directly the racket, travelling up the line C D, hits the ball at G it gets a grip on it and sends it away approximately down the line E F, rotating forwardly and downwardly from G to E. I am in all cases taking the direction of spin from the point of last contact with the racket.

I shall not need here to go into the matters which cause the valuable peculiarities in the flight of this drive. Any student of the game who wants that explanation can find it fully set out in the articles on "Swerve in Bowling," which lately appeared in the cricketing columns of this paper. It will be sufficient for most players to know that the stroke does possess these qualities, and to be told how to get it and take advantage of them.

FIGURE 2.

Showing flight and bound of drive with lift.

Fig. 2 shows very clearly the flight of this ball. When properly played it springs away from the racket rapidly, rotating forwardly and downwardly, as shown by the arrows. Until the initial force of the stroke is overcome by air pressure, the ball flies fairly straight, but immediately the atmospheric friction gets its chance to assert its influence on the rapidly forwardly revolving upper half at C the ball is forced suddenly down, as shown, between C and D. The lower half of the ball is, of course, spinning backwards, and so does not offer anything like the resistance to the passage of the ball through the air as does the upper half.

When the ball strikes the ground at D it is still revolving rapidly forward, and nearly everyone thinks that this ball should grip the ground and shoot suddenly forward. As a matter of fact, it does not, because a superior law says that the angle of reflection shall be equal to that of the angle of incidence. The impact of the ball in its sudden drop is sufficient to momentarily beat the spin, and the ball rises very suddenly. Its momentum and the spin

then again assert themselves, and it darts forward with the long curved bound D E, which will be so familiar to those who saw the Belgian player P. de Borman using his exaggeration of this stroke.

Many and many a time, although I have known the wiles that are in this stroke, have I been tempted to let it go, only to see it dive for the base line like a shot bird, particularly against a wind. A player who understands this stroke can hit the ball harder than he can any other sort of return, and at the same time be more certain of keeping it within the court. Its quick-dropping propensity at the end of its flight is an invaluable quality.

This same quality makes it an invaluable passing shot, particularly for sharp cross-court shots, for the lift makes it find the side lines in quite a wonderful way. Against a volleyer who does not come well up to the net it is a very fine shot. The ball may be made to dive at his feet and fall quite 2ft. or 3ft. short of where it looks like going to. It will be fresh in the memory of many how de Borman, chiefly

by means of "short divers," gathered in sixteen games running at Wimbledon last meeting against a player who is quite satisfied that he knowsthe game.

The stroke should not be allowed to degenerate into mere arm work, as so many of our forehand drives are. It is of the greatest importance to time the body on to the stroke, and this is rarely done here. This drive has another valuable quality which is not possessed in a similar degree by any other ball. It is a natural climber, and should it hit the net a few inches down it will try its best to climb over it, and it is wonderful how often it succeeds.

Fig. 3 shows clearly how this stroke climbs the net. It has been driven into the net at C spinning rapidly from A to B. Directly the rotation is arrested at C the ball, in endeavouring to continue its spin, takes what is practically "running side" (to use the billiard term) from the net and climbs up it so long as the spin can carry it, and in very many cases it gets over where a plain ball will not. This quality is most valuable if a man just happens to be hitting the band.

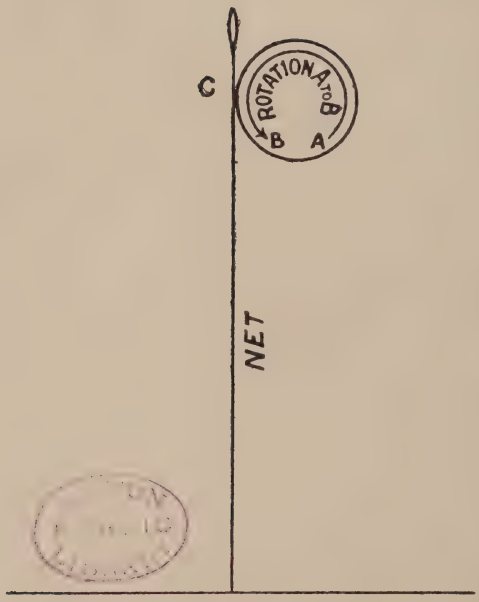

FIGURE 3.

Showing how drive with lift climbs the net.

There is no stroke which allows a player to hit a ball so hard and so high over the net without a risk of putting it out of the court as does this. Many English players trust to natural trajectory to find the base line. It follows that these, if they want good pace, must always drive nearer the net than a good player who has the fore-hand drive with lift. This means, of course, that the man who plays a plain-ball drive has not anything like the margin of error, that most important factor, which is in the power of the expert fore-hand driver who uses lift.

When meeting a player like de Borman, who exaggerates this stroke, it is well to keep in mind the fact that a similar drive will meet and check the spin on the ball, for in matters of rotation "Like answers like" is the rule, whether the spin be moderate or excessive. This is clearly shown in Fig. 4. It may profitably be borne in mind that when returning a drive with lift on it by a similar drive it may, if anything, be dealt with more severely than a plain return, for immediately a fore-hand drive with lift touches a racquet it endeavours to "take its

FIGURE 4.

Showing lifted drive returned by similar stroke. Initial rotation shown by arrow outside ball. Reversed spin after stroke by arrow inside ball.

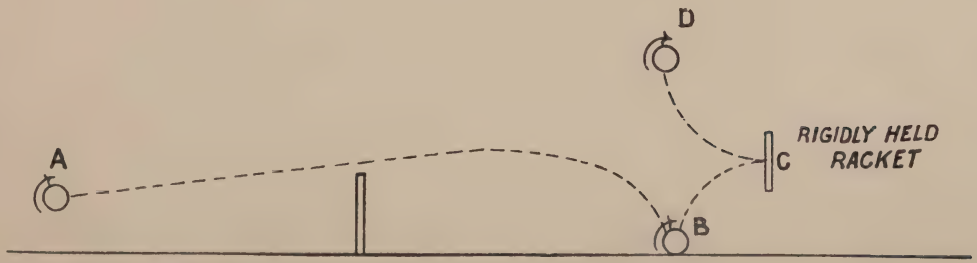

FIGURE 5.

Showing tendencies of drive with lift.

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side," as shown at C D in Fig. 5, so that the striker always has that upward tendency to come and go on in hitting the ball so as to reduce it to a suitable trajectory.

In dealing with a chopped ball by lift, on the other hand, it must be remembered that it has already on it that spin which one intends to impart to it, so that, if it be unthinkingly played as a plain ball with trajectory to just clear the net, it will infallibly find it instead of going over. Dissimilar spins accentuate rotation; similar spins check it. This is quite an important point, and players who desire to develop a first-class modern game should remember it.

I cannot understand why the stroke is not generally used in England, except that possibly it may be that it cannot be conveniently obtained with the defective grip of the racket, which robs English players of about half the strokes in the game. No man who has one hold for all strokes can possibly have in his repertory all the strokes of value in modern lawn tennis; for instance, I should be very sorry to have to play a backhand drive (another stroke which is not known

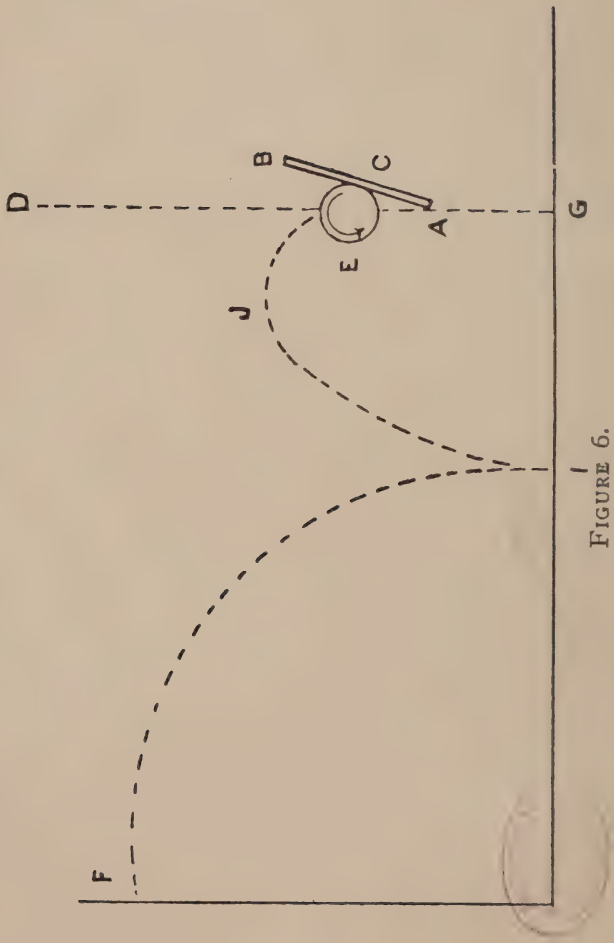

FIGURE 6.

in England) with my hold for the reverse American service.

This stroke, which should be the first ground stroke taught any young player, may be easily learned by anyone who wishes to know it by throwing the ball up against a wall, as shown at F in figure 6, letting it bound at I, and rise to J; then as the ball begins to fall, the racket A B is "brushed" quickly up the line G D so that it hits the ball a glancing blow at C, causing it to spin round, as shown by the arrow, in the direction C E. When you become more expert you may attack the ball before it has risen to the top of its bound.

At first you will merely spin the ball a little, but as soon as you become more expert, and learn to carry your stroke through a little more in the direction of C J, you will be surprised to find that you have a good fast fore-hand drive, which, so far as my knowledge of the game goes, is the only staple fore-hand suited for a first-class player of the modern game.

A command of this stroke almost seems to

give one length. I venture to say that within three years hardly any other fore-hand will be known in the game. Bad length is one of the most prominent faults of English lawn tennis. When the game is resolved into a rush for the net, irrespective of the worth of the "foundation" for that rush, this is not to be wondered at. The proper fore-hand drive would do much to improve the class of lawn tennis in England. It would give better length and sharper, quick-dropping, cross-court passes, and so check much of the indiscriminate rushing which now mars the game to a great extent.

GOLF.

The Flight of a Golf Ball.

AS most golfers know, a ball hit perfectly truly will carry practically straight into the teeth of a strong wind, and it will do so even if the wind be across its line of flight; whereas a sliced ball will curl away at the end of its flight many yards from its true course, especially if the wind happens to be coming in a direction calculated to assist the spin on the ball produced by the slice. Many players will also have noticed the beautiful flight of the push shot; how it skims away across the green like a swallow, and then "towers," to borrow a sporting phrase, and drops as dead as a stone—a regular wind-cheater. These two strokes, the slice and the push, are, in their places, very valuable shots, and are, I think, worthy of slightly more elaborate description as to the methods of their production and their benefits than they have generally received.

I have asked many players what causes a push

FIGURE 1.

Bird's Eye View of a sliced shot.

to keep low for the first part of its journey and then to "tower," and what causes the slice to do nearly all its curl or swerve near the end of the journey, but I have never received a satisfactory explanation. It follows, I think, that, if a player does not know why a ball behaves in a particular manner, he cannot be so well equipped to produce that pecularity as is one who knows what it is that he wishes to get, and how to get it.

The slice is a stroke which most players can play without trying, yet if it be tried as an intentional shot, it is not so simple to play well as one might think. It is caused by the fact that the club head at the moment of striking has left the line of flight from the ball to where it is intended to pitch, and is really travelling across the ball at the moment that it strikes it, as shown in Fig. 1. In this figure for a straight drive to the hole B, the ball would be placed approximately at C, so that the face of the driver D C would meet it at right angles to the intended flight C B. Instead of this, the ball is placed further forward for the slice, as shown at E, and the head of the driver F, which is already beginning to swing inwards, does not strike it truly. This, however, frequently does not affect the flight of the ball very much for, say, two-thirds of its flight, or until the air friction has

FIGURE 2.
Showing flight of push shot.

caused its speed to considerably decrease. Then the spin caused by the glancing blow gets to work, and the wind working on the strong-spinning half of the ball towards H, and there being much less resistance on that half towards the trees, as it is spinning backwards, whereas the other side is spinning forwards, the ball is gradually edged over towards the hole, B.

It will be seen from this illustration how useful a slice may be in getting round an intervening object, which may have stymied a player, for it must be remembered that, even after landing, the natural tendency of the ball is to continue running in the curve of its flight. The slice is useful in a variety of ways, as, for instance, to hold a ball up against the slope of a hill.

To take full advantage of the possibilities of spin on a golf ball a player must thoroughly understand what causes the swerve or curl of a ball in the air. This I am endeavouring to explain in the columns of *The Field*, and anyone interested in the matter should study the articles under the cricket section, headed "Swerve in Bowling" (for all the same principles apply to the swerve of the golf ball). Of course, wind is an important factor in playing a good slice, although, as in cricket, so in golf, it is not an essential.

The push shot is really the tennis stroke, called a "chop." It is illustrated in Fig. 2. A B is the club, C is the ball, and C D the flight thereof. The ball is struck with a downward glancing blow, which does not make absolutely true impact on the ball as the club is carried through and hits or passes very close to the ground by the dot G, instead of as it would do were the shot a clean blow following through directly after the ball. This downward blow naturally puts back-cut on the ball, and it springs away, spinning back towards the player, as shown by the arrow. This back spin is causing it to try to rise the whole time, but until the pace goes off a little it cannot do so. Directly, however, this happens H, which is spinning forwardly with the motion of the ball, begins to assert its extra pace beyond that on the side G, which, although progressing forward, is spinning backward. There is, as H contends with the wind, while G yields, more friction on H than there is on G, and, as a projectile always seeks the line of least resistance, H forces its way into G's track, and so the ball continues to rise until gravitation asserts itself. The ball then drops, and on account of the backward rotation and sudden drop is not a "runner"; but this "soaring" or rising at the end of its flight enables

the master of the stroke to get a very long ball with it.

Strange as it may seem, the principles which govern the flight of the ball in the air are practically with it still in its more lowly "walk" of life on the putting green. What is it that makes the ball hit well forward, and with the putter, if anything, coming up, run so freely, while the ball played with drag hangs, if it be not the modification of those forces already dealt with elsewhere, together with, of course, the greater friction of the grass?

The perfect putt, mechanically speaking, is shown in Fig. 3. A B is a putter with an upright lie, and hinged at A. It follows that, if this be drawn back for, say three inches, and allowed to fall against the ball, so that the same portion of the club strikes it each time, the result will almost infallibly be as nearly as possibly the same as to length and direction each time, provided the experiment be conducted on the same green and the same part of it each time.

Fig. 4 shows a front view of Fig. 3. Although I say that the action in Fig. 3 shows a mechanically perfect putt, it may be open to argument—in fact, it is practically undoubted, that the run on a ball so struck will not be equal to that on a ball

FIGURE 3.

FIGURE 4.

FIGURE 5.

FIGURE 6.

struck as the putter is beginning to ascend, for in a putt played as in Fig. 3 there is the momentary double grip of the putter-face on the ball at C, and also that of the green at D, before the ball begins to move. This is not so with a ball played as in Fig. 6, for it starts rolling directly it is hit. To secure the best results at putting, the two wrists must work together as nearly as possible, like the single joint A, and this, I think, can only be obtained by adopting one of the overlapping grips. Although I am showing putters with an upright lie here, I do not play with that kind, the putter I use being my own design, and having nearly a cleek lie. It is shaped as to the head as shown in Fig. 4, so that, as should be the case in all clubs, the ball is hit in line with the shaft. This will come in due course, as it has in every other game, except hockey and tennis. The lie most suitable for the majority of players is between these two extremes.

Fig. 5 shows a putt played with drag, as so many professionals do. On a fairly level green I cannot see that this putt has any particular advantage, except that it will not run round the lip of the hole to the same extent as will a putt with top on it. Of course, one can hit it harder, but one should be able to obtain an equally good

result by hitting a putt, plain or with "top," a little easier. Drag and cut, of course, are most useful on undulating or sloping greens. I am inclined to think that before long this chopping on the ground will be numbered amongst those strokes which were counted incorrectly played unless one had a half pound divot to replace—or more likely to forget.

Fig. 6 shows a putt played with top. In this case, as will be seen, the putter, A B, has passed the perpendicular, A C, and is beginning to ascend before the face hits the ball, so that at the moment of impact the ball begins to roll, without that temporary "slip," as engineers call it, that there is in every putt played as in Fig. 3, before the ball begins to revolve. The dragged putt is the slowest, the plain hit putt the medium-paced, and the putt with top the fastest of the three different strokes shown here. Some players claim to get top by a turn over of the right wrist at the moment of impact. It can be obtained with far greater certainty by playing the ball as described in Fig. 6. It must be remembered that none of the figures are drawn to scale.

To play a putt with drag the ball should be well back to the right foot, not more than six inches in front of it; for an ordinary putt so that at the

moment of impact the line of the club-shaft is practically vertical when one is facing the player, as in Fig. 3; for a put with top, the ball should be taken nearly off the left toe.

Spin or rotation does not enter so largely into the science of golf as it does into that of lawn-tennis, cricket, and other games; but it is in many cases of great value, and a knowledge of it will do much to assist one who desires to become a first-class player. On undulating or sloping greens a full knowledge of the use of drag top, &c., is invaluable.

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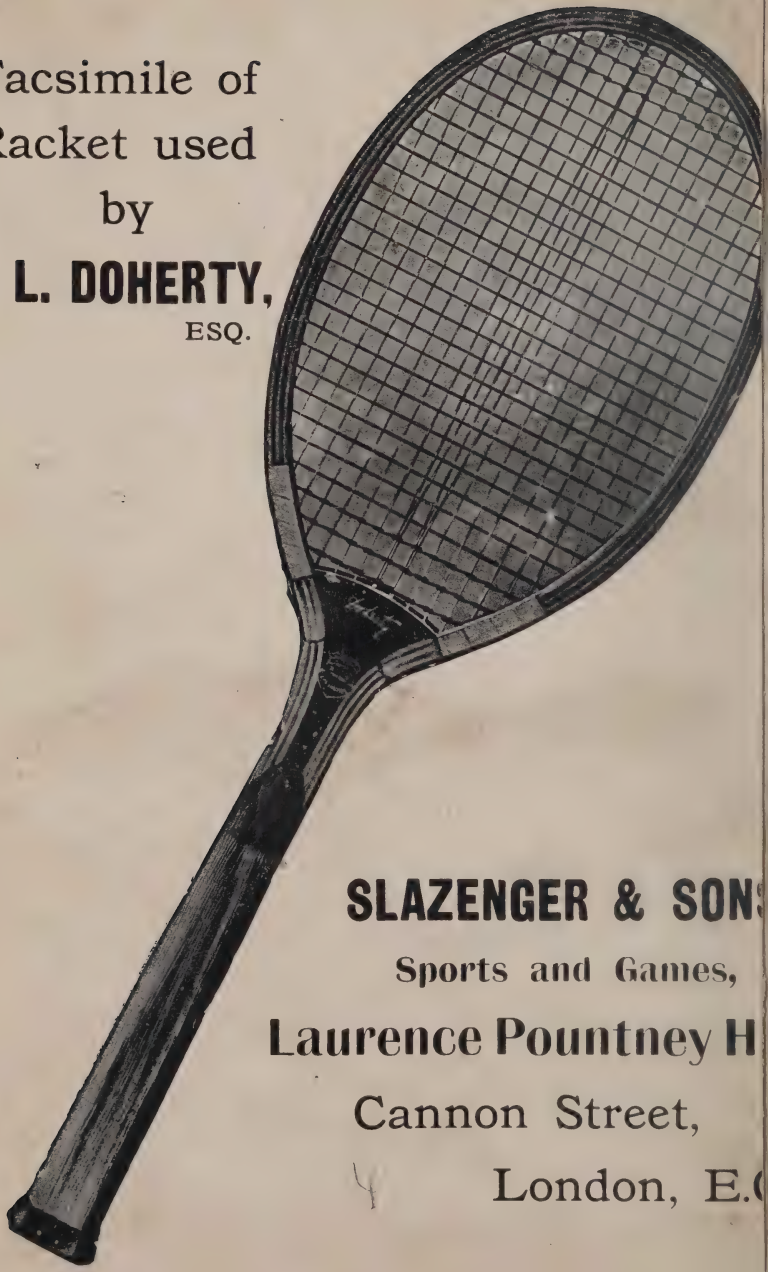

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